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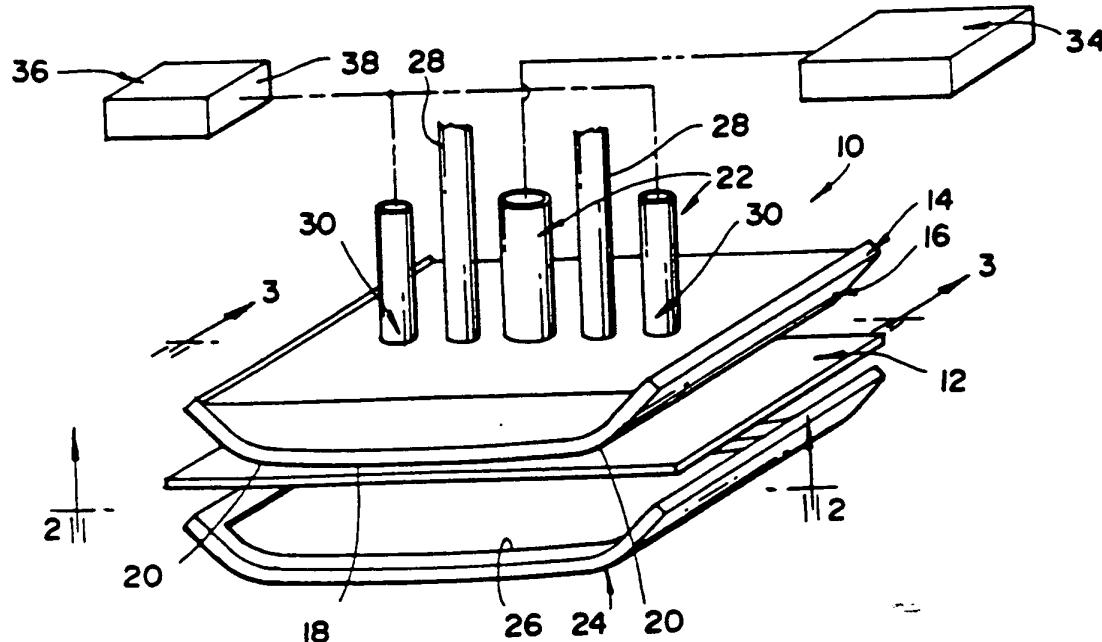
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(54) Title: VACUUM PLATEN FOR SHARP BENDS



## (57) Abstract

Apparatus (10) for bending glass sheets (12) disclosed provides press bending between a shaping surface (16), and a press ring (26) of a complementary shape. The apparatus (10) utilizes vacuum drawn through vacuum chambers (22, 30) and thereby on the shaping surface (16), to control the bending and avoid negative curvature associated with press bending sharp bends into glass sheets (12).

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VACUUM PLATEN FOR SHARP BENDS

TECHNICAL FIELD

This invention relates to an apparatus for press bending sharp bends in flat glass sheets.

BACKGROUND ART

5

Conventional press bending of a glass sheet is typically accomplished by heating the glass sheet to its bending temperature, positioning the glass sheet between a pair of cooperating press bending molds having complimentary shaping surfaces, bringing the shaping surfaces against the glass sheet and subsequently applying pressure to press bend the glass sheet so that it conforms to the shape of the shaping surfaces.

15        Typically one bending mold is convex and has a full surface, and the other is concave and is in the form of a ring. When the shaping surfaces have a non-abrupt curvature, the resultant bent glass sheet usually has a predictable contour and good visual properties. However, when the shaping surfaces include an abrupt curvature, the contour of the resulting bent glass sheet is not predictable and its visual properties are typically disfavorable. This unpredictable contour results because negatively curving areas are formed in the bent glass sheet. These negatively curving areas 20        are created in the areas adjacent the abrupt curvature when the glass sheet separates from the convex surface, as the concave ring shape is pressed toward the convexly shaped surface during the bending. A fulcrum is created by the crease in the convex shaped surface and the glass 25        is strong enough to resist bending over that crease. On either side of the fulcrum, separation of the glass 30

sheet from the shaping surface is likely as the glass sheet is bent.

U.S.P.N. 4,229,200 discloses a glass bending apparatus for use in drop forming glass sheets which includes a downwardly facing vacuum through which a vacuum is applied at a pair of spaced edge chambers and an intermediate center chamber. Such a construction is stated in the patent to allow the central portion of the glass sheet to be released either before or after its edges in order to control the manner in which bending takes place.

DISCLOSURE OF INVENTION

An object of the present invention is to provide an apparatus for press bending sharp bends into glass sheets. Negative curvature and disfavorable optical qualities are avoided when the bending is performed utilizing the invention.

In carrying out the above object and other objects of the invention, the apparatus for press bending a heated glass sheet comprises a first bending mold having a shaping surface. The shaping surface includes a first portion and a second portion having a more abrupt curvature relative to the first portion. A first vacuum chamber draws a vacuum on the shaping surface and supports the glass sheet during bending. A second vacuum chamber draws a greater vacuum on a section of the first portion of the shaping surface that is adjacent the second portion. A second bending mold has a peripheral surface of a complimentary shape to that of the shaping surface. An actuator provides relative movement between the first and second bending molds to press bend the heated glass sheet. The glass

sheet is maintained in contact with the shaping surface as the glass sheet is press bent and thereby negative curvature in the bent glass sheet is avoided.

In the preferred embodiment of the invention  
5 the shaping surface is downwardly facing and also generally of a convex shape. The peripheral surface is upwardly facing and generally of a concave shape to compliment the shape of the downwardly facing convex shaping surface. Perforations are included in the  
10 shaping surface for drawing the vacuum on the shaping surface.

In the preferred embodiment of the invention  
the downwardly facing shaping surface includes a cloth covering to prevent the glass sheet from being marked by  
15 the shaping surface. A separate vacuum unit supplies vacuum to each vacuum chamber and a control is provided for regulating the vacuum applied to the second chamber.

The objects, features, and advantages of the present invention are readily apparent from the following detailed description of the best mode for practicing the invention when taken in connection with  
20 the accompanying drawings.

#### BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is a perspective view of an apparatus  
25 for press bending a heated glass sheet in accordance with the present invention;

Figure 2 is taken along line 2-2 in Figure 1 and illustrates a shaping surface having perforations therein and also illustrates first and second vacuum  
30 chambers;

Figure 3 is a sectional view taken along the line 3-3 in Figure 1 illustrating the vacuum chambers in the first bending mold;

5       Figure 4 is an elevational view of the first bending mold receiving a glass sheet from a roller conveyor;

Figure 5 is an elevational view following Figure 4 showing the glass sheet lifted above the roller conveyor;

10       Figure 6 is another elevational view following Figure 5 and illustrating a second bending mold positioned beneath the first bending mold and glass sheet; and

15       Figure 7 is an elevational view illustrating the press bending of the glass sheet between the first and second bending molds.

BEST MODE FOR CARRYING OUT THE INVENTION

Referring to Figure 1 of the drawings, an apparatus for press bending is generally indicated by reference numeral 10 and is used for press bending sharp bends into heated glass sheets herein indicated by reference numeral 12. As is more fully hereinafter described, the press bending apparatus 10 eliminates negative curvature and resultant disfavorable optical quality associated with press bending sharp bends in flat glass sheets 12.

Apparatus 10 comprises a first bending mold 14 having a shaping surface 16. The shaping surface 16

includes a first portion 18 and a second portion 20 having a more abrupt curvature relative to the first portion. A first vacuum chamber 22, best seen in Figure 3, is used to draw a vacuum on the shaping surface 16 and support the glass sheet 12 on the first bending mold 14 during the bending. A second vacuum chamber 30, best seen in Figure 3, is used to draw a greater vacuum on the shaping surface 16 at the first portion 18 of shaping surface 16 adjacent the second portion 20.

With further reference to Figure 1, a second bending mold 24, preferably a press ring, has a peripheral surface 26 of a complimentary shape to that of a shaping surface 16. An actuator 28 is operable to provide relative movement between the first and second bending molds 14,24 in a registering fashion to press bend the heated glass sheet 12 therebetween. The greater vacuum drawn in the second vacuum chamber 30 thereby maintains contact of the glass sheet 12 with the shaping surface 16 and specifically in the relatively flat area of the first portion 18 adjacent to the area of abrupt curvature 20 as the glass sheet is press bent and thereby negative curvature of the bent glass sheet in the relatively flat area is avoided.

In the preferred embodiment of the invention shown in Figures 1, 2 and 3, the shaping surface 16 is downwardly facing and generally of a convex shape. Likewise the peripheral surface 26 is upwardly facing and generally of a concave shape to compliment the shape of the downwardly facing convex shaping surface 16. As shown in Figure 2 the shaping surface 16 includes perforations 32 therein for drawing the vacuum on the shaping surface. The perforations 32 are preferably more concentrated in that portion of the shaping surface

16 where vacuum is drawn by the second vacuum chamber 30  
and of a smaller diameter to prevent unwanted impres-  
sions on the glass sheet 12.

In the preferred embodiment of the invention,  
5 a cloth covering (not shown) covers the downwardly  
facing shaping surface 16 to prevent the glass sheet 12  
from being marked by the shaping surface during the  
bending. Preferably, the covering is a fiberglass  
covering although other heat resistant cloth coverings  
10 may be used. In Figures 1 and 4 through 7, apparatus 10  
is shown as including two vacuum units 34 and 36 for  
supplying vacuum to the vacuum chambers 22,30.

Vacuum units 34 and 36 supply a low vacuum to  
chambers 22 and 30 respectively for supporting the glass  
sheet 12 on the shaping surface 16 while assuring that  
15 the textured pattern of the cloth is not impressed onto  
the glass sheet surface. A control 38 is operable for  
regulating the vacuum in unit 36 and chamber 30 to a  
high level as the glass sheet 12 is press bent for  
20 maintaining contact of the glass sheet with the shaping  
surface 16 at the first portion 18 adjacent the second  
portion 20.

#### OPERATION OF THE APPARATUS

Figures 4 through 7 are sequential illustra-  
25 tions of the glass sheet bending apparatus 10 showing  
the fundamental operation of the apparatus in a glass  
bending operation.

Figure 7 illustrates the glass sheet 12 having  
been heated to its glass bending temperature in a glass  
heating furnace, not shown, and subsequently positioned  
30 on a roller conveyor 40, situated beneath the shaping

surface 16 of the first bending mold 14. In this position of the glass sheet 12, vacuum is supplied by vacuum units 34 and 36 to the first and second vacuum chambers 22,30 to initiate support for the glass sheet 12 on the downwardly facing shaping surface 16 of the first bending mold 14.

Actuator 28 is then operated to raise the first bending mold 14 with the glass sheet 12 suspended therebelow to a raised position above the roller conveyor 40 as shown in Figure 5 so that the second bending mold 24 having the upwardly facing peripheral surface 26 can be movably positioned beneath the glass sheet and similarly the first bending mold 14, as seen in Figure 6. In this position the glass sheet 12 is in a position to be press bent between the first and second bending molds 14,24 respectively.

Actuator 28 is then operated to provide relative movement between the first and second bending molds 14,24 to move the bending molds toward one another to press bend the heated glass sheet 12 between the shaping surface 16 of the first bending mold 14 and peripheral surface 26 of the second bending mold 24. This press bending action is shown in Figure 7. At the same time the first and second bending molds 14,24 are moved from their respective location in Figure 6 to the registering position shown in Figure 7, control 38 is operated to draw a greater vacuum in the second vacuum chamber 30, shown in Figure 3, and thereby a greater vacuum is drawn on the shaping surface 16 at the first portion 18 of the shaping surface adjacent the second portion 20 to thereby hold the glass sheet 12 in contact with the shaping surface as the bend progresses whereby negative curvature in the glass sheet adjacent the area of abrupt curvature is avoided.

While the best mode for carrying out the invention has herein been described in detail, those familiar with the art to which this invention relates will recognize various alternative designs and embodiments for practicing the invention as defined by the following claims.

WHAT IS CLAIMED IS:

1. Apparatus (10) for press bending a heated glass sheet (12) comprising: a first bending mold (14) having a shaping surface (16); said shaping surface (16) including a first portion (18) and a second portion (20) having a more abrupt curvature relative to the first portion (18); a first vacuum chamber (22) for drawing a vacuum on the shaping surface (16) and supporting the glass sheet (12) thereon during bending; a second vacuum chamber (30) for drawing a greater vacuum on the shaping surface (16) at the first portion (18) adjacent the second portion (20); a second bending mold (24) having a peripheral surface (26) of a complementary shape to that of the shaping surface (16); an actuator (28) for providing relative movement between the first and second bending molds (14,24) to press bend the heated glass sheet (12); said second vacuum chamber (30) thereby maintaining contact of the glass sheet (12) on the shaping surface (16) at the first portion (18) adjacent the second portion (20) as the glass sheet (12) is press bent to thereby avoid negative curvature in the bent glass sheet (12).

2. An apparatus (10) as in claim 1 wherein said shaping surface (16) is downwardly facing and also generally of a convex shape.

3. An apparatus (10) as in claim 2 wherein said peripheral surface (26) is upwardly facing and generally of a concave shape to complement the shape of the downwardly facing convex shaping surface (16).

4. An apparatus (10) as in claim 1 further including perforations (32) in the shaping surface (16) for drawing the vacuum thereon.

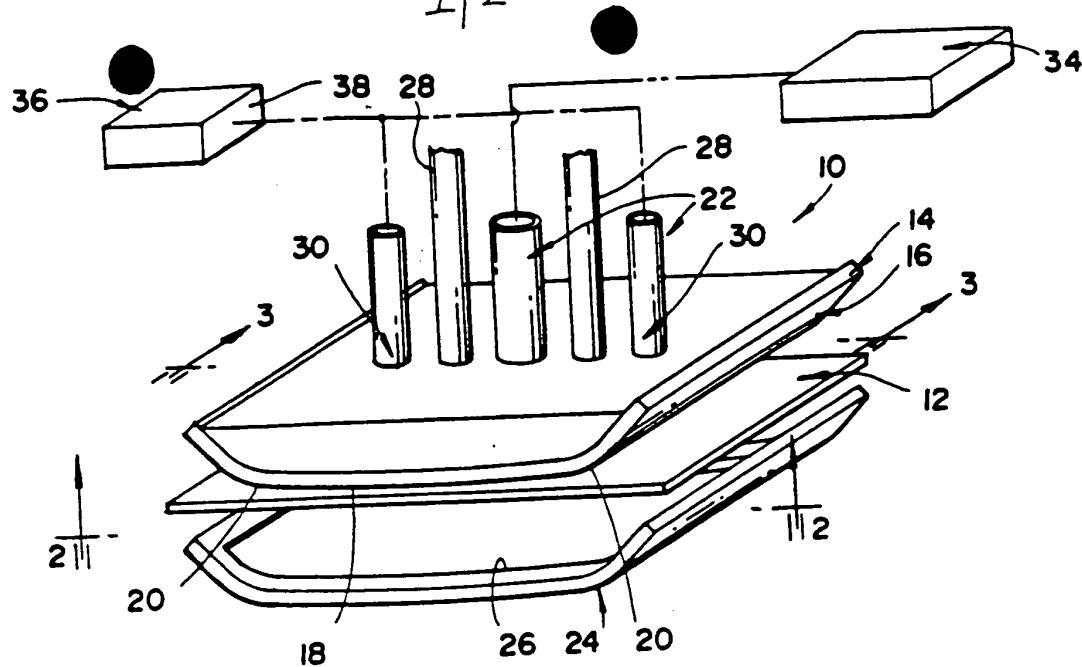
5. An apparatus (10) as in claim 4 wherein said downwardly facing shaping surface (16) includes a cloth covering to prevent the glass sheet (12) from being marked by said shaping surface (16).

5 6. An apparatus (10) as in claim 1 further including a vacuum units (34) and (36) for supplying vacuum to the vacuum chambers (22,30).

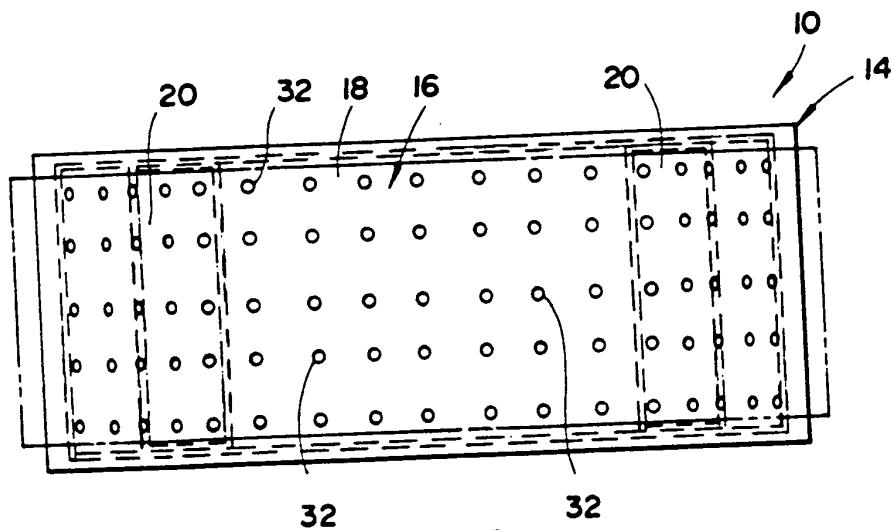
10 7. An apparatus (10) as in claim 6 further including a control (38) for regulating the vacuum level in the second vacuum chamber (30).

15 8. Apparatus (10) for press bending a heated glass sheet (12) comprising: a first bending mold (14) having a downwardly facing shaping surface (16); said shaping surface (16) including a first portion (18) and a second portion (20) having a more abrupt curvature relative to the first portion (18); a first vacuum chamber (22) for drawing a vacuum on the shaping surface (16) and supporting the glass sheet (12) thereon during bending; a second vacuum chamber (30) for drawing a greater vacuum on the shaping surface (16) at the first portion (18) adjacent the second portion (20); a second bending mold (24) having an upwardly facing peripheral surface (26) of a complementary shape to that of the shaping surface (16); and an actuator (28) for providing relative movement between the first and second bending molds (14,24) to press bend the heated glass sheet (12); said second vacuum chamber (30) thereby maintaining contact of the glass sheet (12) on the shaping surface (16) at the first portion (18) adjacent the second portion (20) as the glass sheet (12) is press bent to thereby avoid negative curvature in the bent glass sheet (12).

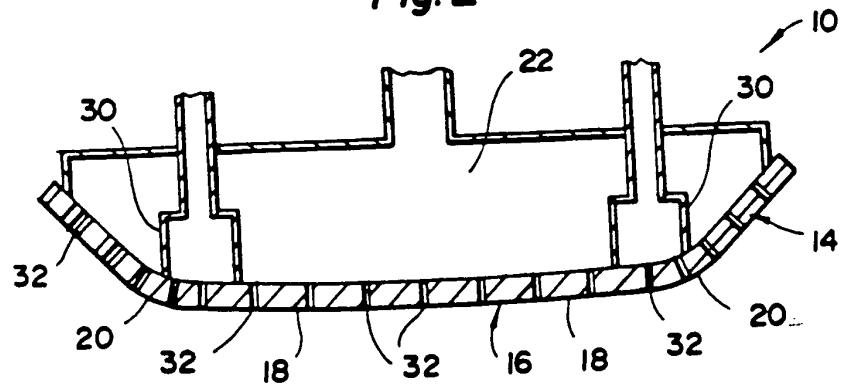
9. Apparatus (10) for press bending a heated  
glass sheet (12) comprising: a first bending mold (14)  
having a downwardly facing shaping surface (16) of a  
generally convex shape; said shaping surface (16)  
5 including a first portion (18) and a second portion (20)  
having a more abrupt curvature relative to the first  
portion (18) and also having perforations (32) therein  
the shaping surface (16); a first vacuum chamber (22)  
for drawing a vacuum on the shaping surface (16) and  
10 supporting the glass sheet (12) thereon during bending;  
a second vacuum chamber (30) for drawing a greater  
vacuum on the shaping surface (16) at the first portion  
(18) adjacent the second portion (20); a second bending  
mold (24) having an upwardly facing peripheral surface  
15 (26) of a generally concave shape and also of a com-  
plementary shape to that of the shaping surface (16); an  
actuator (28) for providing relative movement between  
the first and second bending molds (14,24) to press bend  
the heated glass sheet (12); and a control (38) for  
20 regulating the vacuum level in the second vacuum  
chamber (30) whereby said second vacuum chamber (30)  
maintains contact of the glass sheet (12) on the shaping  
surface (16) at the first portion (18) adjacent the  
second portion (20) as the glass sheet (12) is press  
25 bent to thereby avoid negative curvature in the bent  
glass sheet (12).



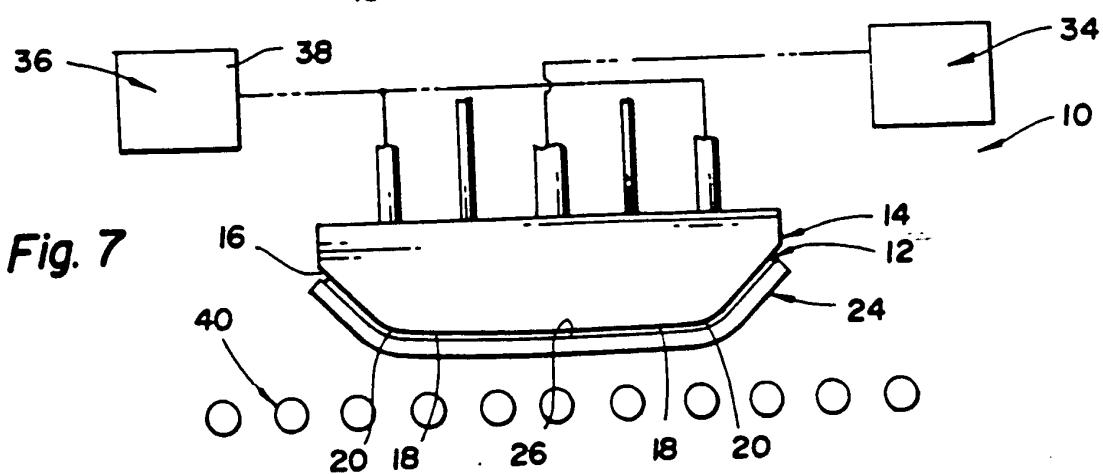
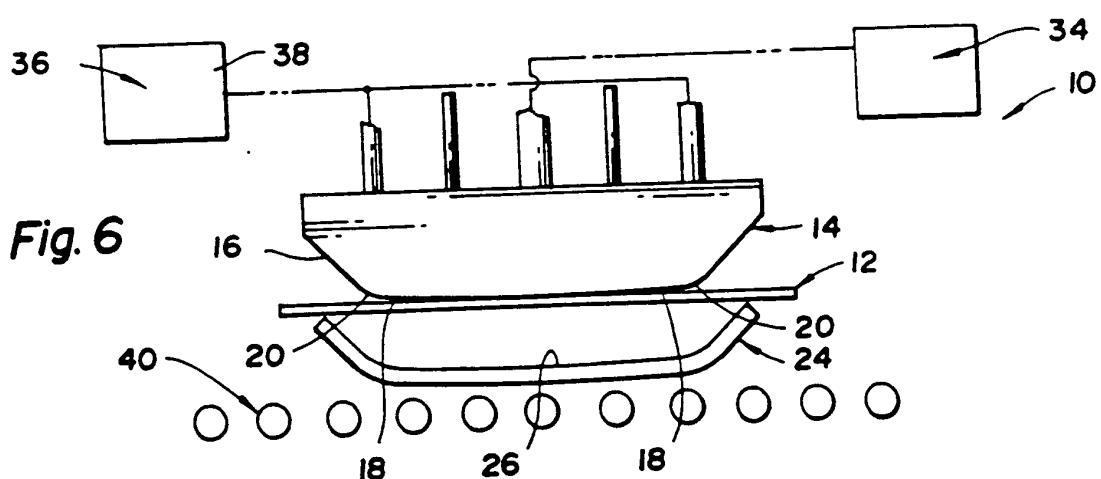
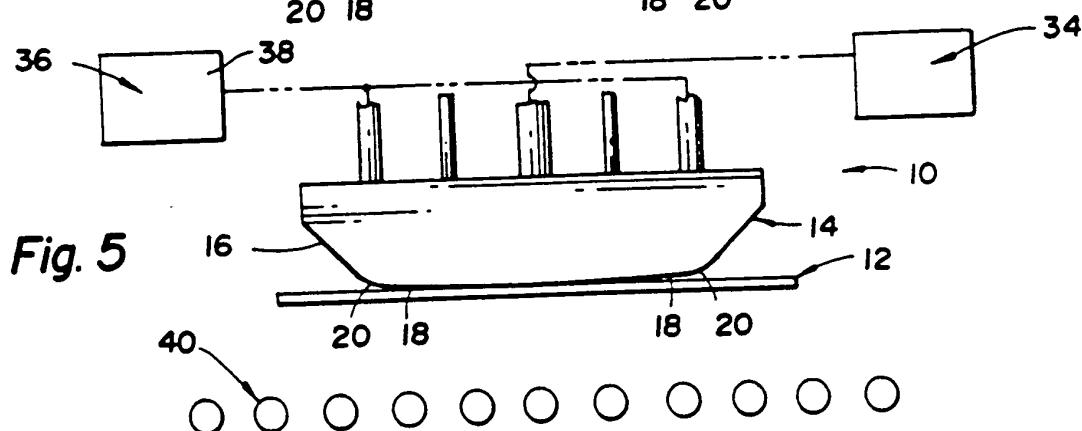
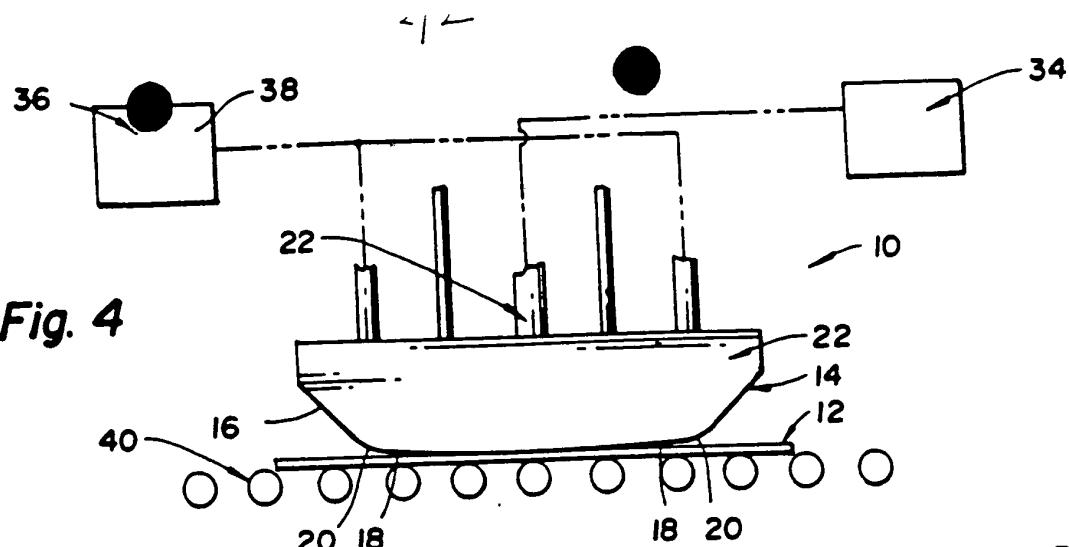
*Fig. 1*



*Fig. 2*



*Fig. 3*



## INTERNATIONAL SEARCH REPORT

International Application No. PCT/US89/01680

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) <sup>6</sup>

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(4): C03B 23/03  
U.S.C1. 65/273, 287

## II. FIELDS SEARCHED

Minimum Documentation Searched <sup>7</sup>

Classification System	Classification Symbols
U.S.	65/106, 273, 275, 287
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched <sup>8</sup>	

III. DOCUMENTS CONSIDERED TO BE RELEVANT <sup>9</sup>

Category <sup>10</sup>	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>
X Y	US, A, 4,470,837 (Seymour) 11 September 1984, see column 6, line 58 -column 7, line 17.	1-6,8,9 7
Y	US, A 3,846,104 (Seymour) 05 November 1974, see column 6, lines 4-19, column 10, lines 66-70 and column 11, lines 27-47.	1-9

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## IV. CERTIFICATION

Date of the Actual Completion of the International Search

18 MAY 1989

International Searching Authority

ISA/US

Date of Mailing of this International Search Report

17 JUL 1989

Signature of Authorized Officer

Joye Woodard  
JOYE WOODARD